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ABSTRACT

The current state of computer assisted instruction (CAI) in kindergarten through grade 12 is discussed. Four formats for CAI--drill, practice, tutorial, and simulation--are defined, and a set of criteria for distinguishing between effective and ineffective CAI are described. Comparisons are made between human and computer tutors. In response to teachers' concerns that CAI demonstrate superiority over textbooks, specific recommendations from the literature are provided for presenting text in a way that maximizes learner comprehension and for constantly monitoring learner readiness to absorb content information presented by computer programs. Suggestions are included for designing tutorial programs, with an emphasis on the importance of text presentation and proper specification of behavioral objectives. Finally, it is noted that simulation programs have the potential to develop higher levels of cognitive functioning. (3 references) (GL)

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COMPUTER ASSISTED INSTRUCTION: EFFECTIVENESS AND TEXT

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The Computer in the Classroom

Students in kindergarten through twelfth grade schools have access to more than one million computers. The typical elementary school has more than six while the high school has more than 20 computers. The number of computers increases with the educational level so that in four year institutions, 69 percent have more than 50 and 18 percent have more than 250. Over 100 studies using primary data describe the effects of computer assisted instruction. What do these studies reveal about the state of CAI? Since text presentation is crucial to the success or failure of instructional programs, research on this topic will be reviewed.

Format of CAI

CAI is a generic term including four different formats: drill, practice, tutorial, and simulations.

In drill, the program presents a problem and prompts for an answer with questions requiring factual responses which depend on memory. Factual learning on the knowledge level is reinforced in drill CAI.

In practice, the program differs from drill in that students, in order to generate a correct response, must apply a rule. Because the student needs to do more than memorize a response, practice requires a higher order thinking skill than drill.

Tutorials teach vocabulary or concepts and then prompt for responses which can be made in natural language. Responses to questions in a tutorial can trigger remedial information or proceed with the program. Text is the primary mode of instruction and the text format, the frame, is followed by questions.

Simulations, a new format in CAI, strives for a higher level of cognitive functioning by providing the student with a variety of responses. Simulations encourage the skill of synthesis by applying what the student already knows to a unique situation. A simulation used in history classes simulates social mobility in France during the reign of King Louis XIV. The program models the economic and social life of a French gentleman with the student making decisions on managing income, property, marriages and estates.

Defining Effective CAI

How is effectiveness in CAI defined and what criteria is used to distinguish effective from ineffective CAI? Effective CAI is most often defined as increasing achievement but other criteria such as change in attitude, reduced learning time, course completion rates, retention of skills, and cost effectiveness may be appraised.

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Research conducted at all educational levels confirms that achievement using CAI is inversely related to instructional level. CAI is most effective at the elementary school level, decreases at the secondary level and is lowest at the college level (Niemiec,1987).

Moreover, there is an inverse ratio between the results of research on CAI effectiveness and computer accessibility. Fewer computers are available in elementary schools where CAI is most effective and more computers are accessible in college where CAI is least effective.

CAI is significantly more effective than average with children with special needs in elementary schools . Current reviews of research do not include handicapped college students in order to determine whether CAI significantly improves learning at all levels of instruction. CAI is highly effective for special needs children with emotional disabilities and mental retardation in elementary schools and further research is needed to evaluate the effect of CAI with hearing and visually impaired students.

Tutoring is More Effective than CAI

Overall, the effectiveness of CAI is moderate. It is second to tutoring in increasing learning. CAI will teach as well as human teachers with some savings in time. Students respond well to CAI and bring enthusiasm to the new technology. CAI proved to be less effective than a tutoring program but more effective than lengthening the school day or reducing class size.

Teachers and CAI

Teachers manage computer assisted instruction and are the most essential part of the management team which includes department chairpersons, assistant principals and computer coordinators. CAI teams throughout the country spend billions of dollars for hardware and software. Crucial to wise expenditures is the ability to evaluate CAI - to know how to purchase the best and discard the worst. Research findings can be helpful by guiding the purchaser to essential elements in CAI.

Teachers reject computer assisted instruction if it is nothing more than an electronic page turner. The vast expense for computers can only be justified if computers can be more efficient than printed textbooks. Both modes of instruction, the book and the computer display require text. How should text in CAI be presented so that it demonstrates superiority over the book?

CAI has the advantage of having intrinsic interest for learners because of its initial introduction as video games. When graphics and animation are added to text, students who dislike reading books are willing to read text on a monitor. Moreover, CAI has the potential for individualizing instruction but as networking systems become widespread, there is the danger that computer labs will resemble traditional classrooms.

Text Presentation

How much time does the learner need to read the text? Since there are slow and rapid readers, how can a CAI lesson adapt to all readers? Programs that are learner controlled allow the student to decide whether to proceed, go back, or quit. If the text is complex, the learner should be able to back up and read the previous frame again. Nothing is more frustrating to a reader than to have the screen scroll away before the reading is complete.The International Reading Association recommends that a display contain as many legible double spaced lines as the screen can hold.

A rapid reading pace leads the student through an entire paragraph at a rate that is faster than usual. This technique of "leading" which is recommended by researchers, can help readers who understand the text to read faster but it presents problems for poor readers. A hesitant learner reads slowly for fear of missing important words. Since the ability to understand text is closely tied to prior knowledge of the material, pace and comprehension are closely connected. Students read material quickly, with anticipation of what follows because they possess prior information about the vocabulary and concepts.

Research on visual images reveals that good and poor readers have equivalent visual ranges. Both readers can span six or seven characters to left and right of each eye fixation. Words outside of this range will not be seen. This research assumes that readers need to examine each character in order to decode for meaning. Further research is needed to determine if character identification is needed on a display screen for it is not needed when reading printed material. Reading research reveals that good readers need not read characters or words to comprehend meaning for rapid readers can scan text quickly and comprehend accurately.

Does the color of text contribute to comprehension? The color of the text is less important than the contrast between foreground and background. In a study of adults using different color screens, the highest accuracy was achieved when blue or green letters appeared against a white background or white appeared against black.

Text Comprehension

Will the learner understand the text? Is the language suitable for the age and ability of the learner? What is the student learning from the lesson? What the learner takes from the CAI is the "textbase." Success of a CAI program is judged by the textbase that a student possesses at the completion of the lesson. Will it be the same or different from the text base that the lesson was designed to teach? The two should complement each other: the learner's outcome and the CAI objective.

Three factors determine whether the CAI text will be understood by the learner: parsing or syntax must clearly signal relationships such as conjunctions or pronoun references; representations or designations must be understood; text must build on prior information held by the learner.

Students come to the computer with expectations based on their experiences with the

structure of books. They expect CAI to duplicate the traditional presentation of material where the main idea or topic sentence appears in the first sentence. Following the statement of the main idea are examples which illustrate the idea. These expectations prove to be significant when technical prose is presented in CAI. Experimenting with good and bad examples of technical prose, adults comprehended text when the first sentence provided the main idea of the passage. They expected that the most significant idea would be placed there and spent a long time reading it.

Readers anticipate a traditional expository presentation with a general statement of the theme followed by subordinate statements providing illustrations and examples of the main concept. Each CAI lesson should contain a single topic and not attempt to cover more one concept. Apparently, readers expect that CAI will preserve the traditional presentation of lectures and textbooks which requires an initial introduction of the major theme followed by illustrative examples - all related to a single topic. Cohesion is reinforced by text which appears on the screen as a paragraph rather than a sentence or line. The structure of the paragraph enables the reader to reread and review the significant parts of the text.

These research findings may change as less CAI assumes the appearance of traditional expository prose and takes on higher cognitive functioning using analysis and synthesis but it will not change the need for the learner to control the program in order to move backward, forward, or out of the program.

What help should a CAI lesson provide to help the student who cannot understand the material? CAI should be designed to offer maximum help to students. How can a CAI author anticipate all the possible questions that will trouble a student? A well designed program will provide options to the learner that will define terms, provide examples for unfamiliar vocabulary, and paraphrase in simple terms the concepts in the CAI.

The Readiness of the Learner

The success of a CAI program depends on the readiness of the learner to absorb the material. Readiness is related to prior information that the learner possesses on the CAI topic. Will the learner have prior learning upon which the CAI depends? If not, the CAI will fail unless it can, through help options, instruct the student with information that is required for comprehension. When teachers review a program, they should require that a program branch to help options before proceeding if some students will not understand the material. Since it is very likely that some students will be unprepared for the lesson, teachers should carefully review the availability of help options.

Programs should constantly monitor for reader comprehension and provide assistance such as definitions of unfamiliar words, background information identifying unfamiliar persons, places, or objects, repeating the main idea, and restating information in less technical language. Research with fifth and sixth graders revealed that their comprehension improved when they saw the help options that provided additional information more than the reading group that did not see any of the aids. Readers need help to understand text and reviewers of CAI should pay close attention to this feature and others compiled in Gillingham's (1988) excellent review of research.

In all cases, manuals accompanying CAI should specify which help options exist so that teachers who are unable to preview the software can review the manuals for a comprehensive overview of the CAI. Which terms are defined and which concepts are paraphrased if the initial exposition is not understood by the student? When are examples provided and is text supplemented with graphics? Teachers should beware of glossy brochures promising mastery in difficult concepts and withhold purchase until previewing the manual and software. If possible, a group of students should preview the CAI since teachers cannot always predict which words or ideas students will find troublesome.

Tutorial Programs

Text is particularly significant in tutorials. The excellence of a tutorial depends on the efficiency of the text. Concepts in literature, mathematics, social studies, science are taught through passages of text followed by test questions which monitor comprehension. If the student answers the question correctly, the program continues, if not the program will branch to offer additional information seeking to help the student understand the concept. The program will proceed if students answer questions correctly.

In addition to efficient text, well designed tutorials should include behavioral objectives for the learner so that both the teacher and the students can judge the program. The objectives should not be vague leaving the student and teacher wondering what the program is expected to accomplish. Specific objectives guide the teacher to evaluate results such as: the student will be able to recognize the concept in another situation, identify four characteristics of the concept, compare two examples of the concept, differentiate one example from another, revise a faulty example, invent a new one, define the concept, recall the names of persons associated with the topic. A reviewer of CAI should evaluate a program on the extent to which the behavioral objectives specified are achieved by the learner. Did the student learn what the program promises to teach?

Tannenbaum (1988) suggests that tutorials include a pretest to determine whether the student has already mastered the information in the program. Pretest responses can determine whether all or part of the lesson can be skipped or whether the lesson is too advanced for the student. Pretests are diagnostic tools and can insure that the level of CAI is appropriate for the student.

Simulation CAI

There is an air of euphoria among CAI users which stems from the belief that the drill or practice format is giving way to formats requiring high levels of cognitive functioning and more creative instructional presentations. Simulations are the result of the most advanced CAI design for they permit the learner to explore and manipulate variables in a design which approximates a real situation. More variation in learner response is possible in simulation than in any other CAI format.

Summary and Conclusions

CAI is more successful in elementary schools and with special needs children and less successful in higher education. Since most of the CAI used has been of the drill and practice format, it is important to continually monitor CAI effectiveness when tutorial and simulation formats become available in the schools. Higher levels of education demand higher thinking skills such as comprehension, analysis and synthesis and few software programs used in CAI utilize these skills.

Effectiveness of CAI will change as research into variables such as text, graphics, questioning, branching, guides software developers and reviewers on to sound pedagogical and cognitive ground.

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